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HUMAN RESOURCES

OPERATIONAL TESTING OF ASCII CODAP JOB AND TASK CLUSTERING METHODOLOGIES

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The ASCII CODAP programs developed to enhance occupational analysis capability were operationally tested on a number of example data sets representing several recently completed occupational analysis projects. Using such examples, the operational testing compared several algorithmically derived solutions with those actually made by experienced analysts. Feedback from such tests were used to further refine and adjust the algorithms used to identify potential job and task clusters. New displays and adapted CODAP products needed for an analyst to make final job type or task module decisions were developed and their utility tested in actual use. The overall result of the testing suggests that the advanced technology can be highly useful in assisting analysts to make realistic decisions, but that considerable skill and judgment are still needed to properly assess the significance of alternative sets of jobs or task modules. With these new tools, however, an experienced analyst should be able to considerably reduce the amount of time required to accomplish an occupational analysis project.

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SUMMARY

The ASCII CODAP programs developed to enhance occupational analysis capabilities were operationally tested on a number of example data sets representing several recently completed occupational analysis projects. Using such examples, the operational testing compared several algorithmically derived solutions with those actually made by experienced analysts. Feedback from such tests were used to further refine and adjust the algorithms used to identify potential job and task clusters. New displays and adapted CODAP products needed for an analyst to make final job type or task module decisions were developed and their utility tested in actual use. The overall result of the testing suggests that the advanced technology can be highly useful in assisting analysts to make realistic decisions, but that considerable skill and judgment are still needed to properly assess the significance of alternative sets of jobs or task modules. With these new tools, however, an experienced analyst should be able to considerably reduce the amount of effort required to accomplish an occupational analysis project.

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OPERATIONAL TESTING OF ASCII CODAP JOB AND TASK CLUSTERING METHODOLOGIES

I. INTRODUCTION

The ASCII CODAP refinements developed to enhance occupational analysis capability have been operationally tested on a number of example data sets representing several recently completed occupational analysis projects. Using such examples, the operational testing compared several algorithmic solutions with those actually made by experienced analysts. Feedback from such tests was used to further refine and adjust the algorithms used to identify potential job and task clusters. New displays and adapted CODAP products needed for an analysis to make final job type or task module decisions were developed and their utility tested in actual use.

II. REFINEMENT OF JOB AND TASK GROUPINGS

In a typical occupational study, groups identified as meaningful jobs that are interpreted from a diagram of an occupation will not include all the cases (individuals) in the sample, except at a very low stage, where the overlap values are low. In previous reports (Mitchell & Phalen, 1985; Phalen, Mitchell, & Staley, 1987), we reported the use of an iterative nonhierarchical cleanup procedure to solve this problem and refine the groups. A sample of the results can be seen in Table 1, where groups from the hierarchical clustering account for 80% of the cases and the refined groups output by the nonhierarchical refinement process encompasses 99.2% of the cases (at iteration 6). By computing the percent time overlap of each case's job description with the mean description for every selected group, this procedure permits each unclassified case to be included in the group it most resembles, at a specified minimum level of overlap. The group vector is then recomputed and, in the second iteration and beyond, all cases are compared to the group means. Cases can migrate to the emerging groups they are most like, rather than being forced to remain with the first linkage, as occurs in hierarchical clustering.

Table 1 **OVLGRP--Totals by Iteration (RES 811XX; data from Alton, 1984)**

Iteration	No. classified	No. unclassified	Percent
Diagram	2643	660	80.0
1	3298	5	98.8
2	3292	11	98.6
3	3285	18	99.4
4	3281	22	99.3
5	3279	24	99.3
6	3278	25	99.2

By looking at the movement of cases in and out of groups at each iteration of the nonhierarchical refinement process, we can better understand the dynamics of the process. For example, Table 2 shows three Law Enforcement (LE) groups to illustrate the type of changes that occur. In this case, we can track where the people go since the 22 members lost from the combined Desk Sergeant/Patrol group are the same 22 showing up in the Desk Sergeant group. Note that once these cases are added, the Desk Sergeant group tends to stabilize in terms of size and the variance in overlap of individuals with the group mean drops considerably (SD = 9.2--> 7.3), which is evidence of a more homogeneous group. The LE patrolmen group increases in size and decreases in variance, while the third group does the

opposite. Instead of three groups, we end up with two meaningful groups whose job descriptions should be more realistic pictures of their jobs.

Table 2. **OVLGRP--Details of Example Law Enforcement Group**

Group	Variable	DGRM GRP	Iteration 1	2	3	4	5	6
GRP 594 LE DESK SERGEANT								
	Grp Size	15	37	34	33	32	32	33
	No. Lost	–	–	3	2	1	0	0
	Gained	–	22	0	1	0	0	1
	Mean Ovrlp	–	44.6	42.5	42.7	42.4	42.5	42.6
	SD	–	9.2	7.4	7.6	7.4	7.3	7.3
GRP 921 LE DSK SGT/PATROL								
	Grp Size	90	68	38	20	14	10	5
	No. Lost	–	22	30	18	7	4	5
	Gained	–	0	0	0	1	0	0
	Mean Ovrlp	–	57.4	56.2	56.9	55.3	54.4	49.2
	SD	–	7.2	7.4	8.2	9.9	10.5	10.9
GRP 785 LE PATROLMEN								
	Grp Size	12	38	55	90	84	67	51
	No Lost	–	–	6	12	29	25	20
	Gained	–	26	23	47	23	8	4
	Mean Ovrlp	–	51.0	52.1	55.5	57.2	57.6	57.9
	SD	–	10.9	7.8	7.4	7.2	6.9	5.9

The reclassification of cases in iterative stages is done with the OVLGRP (overlap of cases with group means) program, which identifies new groups of cases which are more internally consistent and may be somewhat easier to interpret in terms of core or characteristic and distinguishing tasks. The interpretation of the groups at each iteration is not an easy task, but better reports are now available to track how cases move among job groups and to analyze new job groups.

A GRPMAT (a table which shows the migration of cases from one job group to another) for the Precision Measuring Equipment Laboratory (PMEL) study is shown as Figure 1. Not all of the 21 Occupational Survey Report (OSR) groups (Aslett, 1984) are shown in this display, in order to simplify the discussion. Note that the job types are shown down the left-hand column and the OVLGRP-refined groups across the top of this display. Those cases not members of any group in OVLGRP are shown as the first column (GRP 02), and the marginal summaries (ST 001) report the size of each group. These data provide some examples of what happens in the reclustering process.

Missing cases (that is, those which migrated out of the group) differed from the rest of the group in terms of their relative time spent on duties. They tended to migrate out in pairs which had some similarity of duty time with the group but usually performed more duties as well.

We need not get totally submerged in the details of this process here. The point is that the reclustering of groups does help to identify distinguishing tasks of various jobs and can be used by an analyst to refine his or her initial job type selections. Major groups are relatively stable in terms of their job descriptions, but some of the smaller groups proved unstable and disappeared. Other small groups involved in specialized missions, such as F-15

equipment maintenance, not only proved stable but increased in size in this iterative regrouping process.

---These are the Job Types from the OSR

These are the Job Types after OVLGRP

v	Unclassified	Grp 141	Grp 096	Grp 322	Grp 238	Grp 140	Grp 243...	Total
ST 141	.	95	2	.	1	.	6	112
ST 096	.	2	160	.	7	7	7	211
ST 322	.	.	.	49	6	11	.	181
ST 238	.	.	.	.	17	1	.	19
ST 140	.	.	.	.	.	82	4	90
ST 243	.	.	.	.	.	2	3	5
.								.
.								.
.								.
Total	63	103	194	49	39 ...	120	62 ...	1513

Figure 1. **GRPMAT--Precision Measuring Equipment Laboratory (PMEL) Personnel.**

The intense analysis work involved in interpreting and evaluating the regrouped job types can be facilitated by using Core Task Analysis and Comparison of Job Descriptions (CORTAS) and Report of Case Background Variable Data in Clustering Order (PRTVAR) outputs for the groups which need to be reanalyzed (those which were not stable as indicated in GRPMAT, or where the analyst wishes an improved job description). This approach reduces the total amount of effort needed to reanalyze the set of Air Force Specialty (AFS) jobs. Another approach uses Automated Pairwise Comparison of Job Types (AUTOJT) runs to compare pairs of groups an analyst wishes to study; such AUTOJT products help to expedite comparing two groups (input versus output groups) and provide a very quick way to highlight the differences between such groups.

III. OPERATIONAL TESTING OF THE NEW APPROACH

To test the new procedures for nonhierarchical refinement of job and task clusters, six AFSs were examined using this approach. Results were quite good and, in general, replicated the United States Air Force Occupational Measurement Center (USAFOMC) analysts' judgments very closely (some slightly more specific, some slightly more general). In Figure 1, note the distribution of cases across input and output groups, with the unchanged core members of each group appearing in the main diagonal. Of 112 cases in Stage 141, 95 remain along with 8 picked up from other groups; this represents relatively little change; thus, there will be no real change in the original job description. For Stage 96, 160 of the original 211 remain, and an additional 34 are added from other groups. A core of 49 people from the original 181 in Stage 322 stayed together and added no new members; the remaining 132 cases were scattered across 8 other groups (not shown).

Stage 238 was a small group of 19; core tasks which discriminate this group have to do with calibrating high frequency (HF) counters, and aligning or troubleshooting electronic counters or spectrum analyzer plug-in units. Seventeen of the 19 cases provided a stable core around which another 22 cases clustered. Examination of the tasks for the new group indicates that the tasks which discriminate the group remain the same, but the percentage of the group performing the core tasks has increased.

In addition to identifying numbers of individuals who move or stay in the various groups, an analyst also needs to examine the background data for these individuals in order to fully understand the significance of the various clusterings. Summaries of such data in clustering sequence (PRTVAR) are routinely used in the normal analysis process. Since members have migrated among groups, the normal diagram sequence is no longer valid; one would have to trace individuals through two sequence numbers case by case. To meet this need, a new PRTVAR option is available which provides a separate product for each of the new job groups and which displays the data in original clustering (KPATH) sequence.

Table 3 reproduces a portion of a PRTVAR for GRP 096 (original Stage 096); the original clustering sequence for the cases in the group was 113 to 323. Much of the original KPATH sequence remains intact (in fact, 160 of 211 cases), with 2 cases added from below the original range. In the upper KPATH sequence, there is more mixing, with some cases migrating in or out. It remains predominately a first job, with about half the members holding a 3-skill-level Air Force Specialty Code (AFSC). There are, however, some 7-skill-level personnel in the group; they perform about the same number of tasks and have a technician title as opposed to calling themselves supervisors or noncommissioned officers in charge (NCOICs).

Table 3. **PRTVAR--GRP 096; Precision Measuring Equipment Personnel**

KPATH	No. tasks	AFSC	Grade	MAJCOM	Base	Job title
100	95	32470	TSgt	SYS	Hanscom	PMEL Technician
102	76	32430	A1C	USAFE	Torrejon	PMEL Technician
113	73	32450	A1C	SAC	Andersen	Prec Meas Equip
114	88	32430	A1C	USAFE	Ramstein	PME Spec
115	106	32430	A1C	ATC	Williams	PMES
116	72	32430	A1C	MAC	Little Rk	PMEL Technician
117	79	32450	Sgt	SAC	Andersen	Precision Meas
118	80	32430	A1C	SAC	Grnd Fks	PMEL Spec
119	64	32430	A1C	ATC	Lowry	PME Spec
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
319	74	32470	TSgt	SAC	Wurtsmith	K 1-9 Sec Spvr
321	108	32470	SSgt	USAFE	Lakenhth	PME Tech
324	77	32450	SSgt	MAC	Bolling	PME Tech
325	63	32470	SSgt	OAR	HQ AF Cen	PMEL Mobile Cal
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
1093	47	32430	A1C	AAC	Shemya	PMEL Tech

The very positive results from the validation testing led us, in one of the monthly CODAP Users' meetings, to volunteer to use the automated procedure for any study where the USAFOMC analyst was having difficulty with an analysis or where more than 10% of the cases were not covered by the identified job types. USAFOMC personnel suggested that a good candidate

specialty would be the Supply AFS (645XX), where almost 50% of the cases were not included in the analyst's final set of selected job types (Caussade, 1988).

Initial trials using the Supply AFS jumped the coverage of cases to 96.9%, which seems to be a dramatic improvement (see Table 4). However, close examination of the GRPMAT, PRTVAR, and OVLGRP products showed an increase in standard deviations and a decrease in mean within-group overlap across iterations--exactly opposite of expectation.

Table 4. **OVLGRP--Total in Each Iteration; July 1988 (AFS 645XX)**

Iteration	No. classified	No. unclassified	Percent
Diagram	1958	1793	52.2
1	3604	145	96.1
2	3624	127	96.6
3	3627	124	96.7
4	3631	120	96.8
5	3634	117	96.9
6	3632	119	96.8

Further analysis of the Supply (AFS 645XX) products suggested that although the unclustered cases were now included in identified groups, the groups were mostly at an unacceptably low level of internal overlap to be considered valid job types. Clearly, the program was not operating appropriately for us to achieve the end for which it was designed. This unexpected outcome led to a complete reexamination of the software.

The problem appears to have been with routines which set the minimum acceptable overlap before a case could be considered a member of a group; the minimum cutoff was not operating as desired. Thus, all cases were being merged with some group, the one which was the "best" fit for the case when compared with all other groups. This routine was rewritten to effect dual minimum overlap cutoff criteria, one that is absolute and one that varies from group to group. If a case does not meet the dual criteria, it is rejected for membership in any group at that iteration (and will be held for reconsideration at the next iteration).

Table 5 displays the results of the revised program. The coverage of cases improved from about 52% to about 71% of the cases, without degrading the job descriptions of the groups. The remaining 29% of the cases were still so divergent that they were not included.

Table 5. **OVLGRP--Total in Each Iteration with Improved Program; October 1988 (AFS 645XX)**

Iteration	No. classified	No. unclassified	Percent
Diagram	1958	1793	52.2
1	2509	1242	66.8
2	2571	1180	68.5
3	2648	1103	70.6
4	2664	1087	71.0
5	2669	1082	71.2
6	2677	1074	71.4

The resulting groups are much more acceptable and have improved face validity. One result was the breakup of one large group of supervisors into smaller groups more directly related to the various technical areas within the specialty. The USAFOMC analyst involved in this study indicated that this made much more sense, in that the smaller groups could be directly related to the technical subareas.

Certainly, the 71% coverage is less than desired, but with automated technology, it may be all that is possible for heterogeneous specialties. When viewed in terms of improvement over the original clustering, it represents a significant gain in group coverage (19%). In addition, the final job groups appeared to be more realistic and more interpretable to the analyst.

For most studies, the improved program should provide for 95% to 99% coverage of cases. There will be some studies (such as the Supply AFS), however, where the AFS is so diverse (or where the jobs are not well structured) that even with the improved program, coverage cannot be more than 70% to 75%. We would maintain that such complex or heterogeneous AFSs are in need of close examination. They may represent areas for possible reengineering efforts (shredouts or functional reorganization).

IV. CONCLUSION

Operational testing of the nonhierarchical refinement of job types has demonstrated that, in most AFSs, very significant improvements can be made in the numbers of members covered by identified job types and in the stability of calculated job descriptions. For some very diverse AFSs, the refinement procedure will help, but will not completely solve the problems which such diversity presents. This refinement technique is another very valuable tool which should help occupational analysts improve and expedite their work.

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